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Historical Questions in Hazardous Waste Management

CRAIG E. COLTEN

ONE CHORE FACING environmental agencies at the state and federal level is the accurate and reliable inventory of relict hazardous waste sites, those abandoned refuse heaps which continue to present health risks. Estimates suggest that hazardous materials were once deposited at more than 16,000 now inactive sites, yet the number of documented cases falls far short of this total.[1] The preoccupation of public agencies with post-1940 synthetic organic chemical wastes has caused investigators to lose sight of a major segment of the country's industrial legacy. The early industrial city bequeathed an abundance of derelict waste disposal ground which has not been fully appreciated.[2] Lewis Mumford graphically described the pervasiveness of manufacturing refuse in the late nineteenth century:

> As witness to the immense productivity of the machine, the slag heaps and rubbish heaps reached mountainous proportions, while the human beings whose labor made these achievements possible were crippled and killed almost as fast as they would have been on a battlefield.[3]

Urban residents also confronted health threats from water tainted by factory effluent.

> There were myriads of dirty things given it [a river] to wash, and whole wagonloads of poisons from dye houses and bleach yards thrown into it to carry away; steam boilers discharge into it their seething contents, and drains and sewers their fetid impurities; till at length it rolls on—here

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1. Michael Greenberg and R. F. Anderson, *Hazardous Waste Sites: The Credibility Gap* (New Brunswick: Center for Urban Policy Research, 1984), 84.
2. See Kenneth L. Wallwork, *Derelict Land* (London: Newton Abbot, 1974), esp. 42–73.
3. Although Mumford referred to the onerous working conditions, part of the high mortality rate was due to toxic materials in the work place. Lewis Mumford, *The City in History* (New York: Harcourt Brace Jovanovich, 1961), 446.

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The Monsanto Chemical Company's Krummrich Works began producing a variety of commercial acids in 1907. Emissions of chlorine and other toxic gases during the 1930s prompted neighbors to file suits against the chemical company, but the local courts seldom awarded damages to the plaintiffs. (Photograph courtesy of the Illinois State Historical Library.)

The Laclede Steel Company, Alton, Illinois, circa 1967. The open lagoons, ditches, and mounds of slag and raw materials typified the use of vacant land for storage and disposal of industrial wastes. (Photograph courtesy of the Illinois State Historical Library.)

> between tall dingy walls, there under precipices of red sand-stone—considerably less a river than a flood of liquid manure.[4]

Some of the offensive wastes churned out during the first half of this century were hazardous, and some remain so. Unless public agencies seriously consider the historical component of our industrial past, their inventories will remain incomplete and only marginally useful.

There are two overriding reasons for making historical analysis an integral component of hazardous waste management policy. First, older sites, some of which continue to present public health threats, received industrial wastes during a period of uncontrolled waste disposal, and many contain substances that are now regulated. Furthermore, many of the sites created during the first half of the twentieth century have undergone subsequent redevelopment. Reworking the urban landscape has erased visible traces of many such sites. Without historical sleuthing, they may remain unknown.

Second, hazards assessment techniques attempt to assign a degree of risk that communities may face from known disposal sites. These techniques rely on databases heavily biased toward recent hazardous waste activity. Lacking a strong historical component, the databases cannot yield satisfactory results in all cases. Inaccurate ranking can lead to misapplication of limited clean-up funds, dislocations of neighborhoods without due cause, and a persistence of reactive public response to hazards.

This paper will review the methods used to identify hazardous waste disposal sites and will analyze their historical weaknesses. It will also offer a brief overview of pre-1940 hazardous wastes and then discuss the treatment and disposal methods used by the industries that created large quantities of troublesome wastes. Since the 1930s was a period of heightened concern with manufacturing wastes, the review of disposal methods will focus on that decade. This will illustrate the scope and nature of environmental contaminants left by industries before the Second World War and will underscore the value of historical contributions to hazardous waste research.

Identifying Historical Hazards

The fact that long-forgotten waste disposal sites could continue to affect nearby populations has not been lost on environmental agencies. The highly publicized case of Woburn, Massachusetts has centered on a late nineteenth-century industrial district[5] and the U.S. Environmental Protection Agency (U.S. EPA) has sponsored research to identify nineteenth-

4. Ibid., 459–60.
5. For a summary of the industrial history of Woburn, see Tufts University, Department of Environmental Policy, *Hazardous Wastes in Woburn* (Medford, Massachusetts, May 1980).

Table 1. Historical Hazardous Waste Sites

Inventory	Number of Sites	Percentage Pre-1950	Percentage Pre-1940
National Priorities List (1981) Waste Disposal Sites	115	24	
National Priorities List (1984) Waste Disposal Sites	538		9
RCRA (1981) Active Treatment, Storage, or Disposal Sites	4,818	6.4	4.7

Sources: Greenberg and Anderson, *Hazardous Waste Sites,* 1984; USEPA, *Hazardous Waste Sites,* 1984; USEPA, *National Survey of Hazardous Wastes,* 1984.

century hazards.[6] The initial National Priorities List (NPL), a preliminary inventory of the country's most hazardous sites prepared by the U.S. EPA, identified a total of 115 sites throughout the country, 24 percent of which received wastes prior to 1950 (Table 1).[7] An expanded list (N = 538) documented contamination in the vicinity of at least forty-eight sites used before 1940.[8] Although the proportion of historical sites declined, the number is significant, particularly in light of the biases for recent sites built into the inventory system.

The development of procedures to track the flow of wastes and to identify disposal grounds has been spearheaded at the national level and has produced systems largely dependent on reports from industries. While practical, they automatically exclude most defunct businesses. The first of the tracking systems came about with the passage of the Resource Conservation and Recovery Act (RCRA) in 1976. It instituted a system to monitor hazardous wastes "from the cradle to the grave," with the goal of preventing accumulations of improperly disposed hazardous wastes in the future. It also sought to identify only active treatment, storage, and disposal facilities. Consequently, a meager 4.7 percent of the facilities inventoried in 1981 were in use before 1941 and the U.S. EPA saw this as a problem with the inventory.[9] Passage of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund)

6. An overview of hazards left by nineteenth-century industries is Vary Coates, *et al.*, *Nineteenth Century Technology—Twentieth Century Problems: A Retrospective Mini-Assessment* (National Technical Information Service, PB 82-242058, 1982).

7. Greenberg and Anderson, *Hazardous Waste Sites,* 127.

8. U.S. Environmental Protection Agency, *Hazardous Waste Sites: Descriptions of Sites on Current National Priorities List, October 1984* (Washington, D.C., December 1984).

9. U.S. Environmental Protection Agency, *National Survey of Hazardous Waste Generators and Treatment, Storage, and Disposal Facilities Regulated Under RCRA in 1981* (EPA 530/SW-84–005, Washington, D.C., April 1984), 103–6.

in 1980 authorized the U.S. EPA "to respond to past, present or potential releases of 'hazardous substances' into the environment."[10] This legislation provides for emergency cleanup activities at priority sites and the creation of an inventory system to identify and rank hazardous waste sites. All suspected sites are evaluated in terms of the hazardous material, local geological and hydrological conditions, and potential targets. Yet many sites have not been disclosed, particularly the older ones. This historical failing reappears in the NPL inventory, which is compiled from the CERCLA listing, and is compounded by the circumstance that less accurate information is available for older sites. Inaccurate or inspecific data can prevent older sites from qualifying for the NPL and this in part explains the low total of pre-1940 sites on the NPL. The under-reporting of inactive sites in the CERCLA inventory prompted the U.S. EPA to develop a separate catalog of abandoned sites. The Emergency Remedial Response System (ERRIS) combines information on inactive sites from both the RCRA and CERCLA inventories to allow separate analysis of abandoned sites. The ERRIS inventory contains more than 16,000 sites, but it is burdened with the same historical shortcomings as its source and is only suggestive of the complete number of inactive sites.[11]

Several states are developing programs to extend the historical reach of inventories. New York has requested information on all hazardous waste disposal activity since 1952, although their system too relies on reports from existing businesses.[12] Currently, Illinois and Washington are developing computerized listings of inactive and active businesses that handled hazardous wastes in the past.[13] These inventories will identify companies left out by self-reporting procedures and assist in the assessment of derelict hazards. The Illinois listing is being augmented by a series of case studies of major industrial districts to account for actual waste disposal practices before 1970.[14]

Despite progress in the approach to past hazards, deeply entrenched attitudes inhibit analysis of historical sources of industrial hazards. The tenfold growth of the organic chemical industry since 1940 has led many investigators to discount the significance of wastes produced before

10. Greenberg and Anderson, *Hazardous Waste Sites*, 68.

11. Ibid., 118.

12. New York Department of Environmental Conservation, *Community Right-To-Know*, vol. 2, *Past Hazardous Waste Disposal Practices* (Albany, New York, April 1985).

13. Sue Schock, *et al.*, *Enhancement of the HWRIC DataBase: 1986*, Illinois Department of Energy and Natural Resources, Hazardous Waste Research and Information Center (Savoy, Illinois, August 1986); and Washington Department of Ecology, *Site Discovery Project: Pilot Program Summary Report* (Olympia, Washington, March 1987).

14. C. E. Colten *Industrial Wastes in the Calumet Area, 1869–1970*, Illinois Department of Energy and Natural Resources, Hazardous Waste Research and Information Center (Savoy, Illinois, September 1985); and C. E. Colten and G. E. Breen, *Historical Industrial Waste Practices in Winnebago County, Illinois: 1870–1980*, Illinois Department of Energy and Natural Resources, Hazardous Waste Research and Information Center (Savoy, Illinois, September 1986).

Table 2. Estimated Volumes of Hazardous Wastes, 1935

Year	Chemical Emps. (1000)	1000 Tons of HW per year*	Metals Emps. (1000)	1000 tons of HW per year*	Leather Emps. (1000)	1000 tons of HW per year*	Total HW per year* (1000 tons)
1950	457	1759	978	4655	342	923	7337
1935	306	1178	792	3770	311	840	5788
1929	550	2118	n.a.	n.a.	319	861	
1919	497	1913	n.a.	n.a.	350	945	
1889	144	554	n.a.	n.a.	250	675	

Sources: Rudolfs and Setter, 1936; U.S. Census, *Historical Statistics*, 1976.
*The volume of hazardous wastes for each industry represents 10 percent of the estimate for all wastes using a multiplier developed by Rudolfs and Setter in 1936.

then.[15] They assume that few hazardous materials were discarded and that the small quantities that were produced do not warrant serious consideration. Yet estimates of industrial waste production in 1935 illustrate that chemical producers, primary metal firms, and tanneries emitted substantial hazardous wastes.[16] Based on a 1935 survey of New Jersey industrial wastes, I have estimated that U.S. chemical, primary metal, and tanned leather goods manufacturers accounted for approximately 5.7 million tons of hazardous wastes (Table 2), and a more complete accounting of all industries would undoubtedly raise the total. Among the wastes released in the mid-1930s were a variety of acids, toxic metals, carcinogenic solvents, and oils—all classified as hazardous materials by current law. While the level of hazardous waste generation in 1935 is far lower than the current estimates of 190 million tons annually, sizable amounts were produced.

Another reason to discount historical wastes is the supposition that older sites no longer contribute to public health problems, that the hazardous materials would deteriorate or become diluted through the years. A review of the problems caused by the forty-eight NPL sites predating 1940 discredits this argument (Table 3). Persistent ground- and surface-water contamination has resulted from such typical turn-of-the-century industries as wood preservers, paint manufacturers, chemical plants, watch factories, smelters, local gas works, pesticide producers, and mining operations. Similar long-term releases of toxic materials in English

15. Currently the industrial chemical industry generates an estimated 400 billion pounds of hazardous wastes annually. See David J. Sarokin, *et al.*, *Cutting Chemical Wastes* (New York: An INFORM Report, 1985), 16–19.

16. Willem Rudolfs and Lloyd R. Setter, *Industrial Wastes in New Jersey*, New Jersey Agricultural Experiment Station, Bulletin 610 (November 1936). The authors surveyed the wastes of more than 1,900 industries and based their estimates of industrial wastes on measurements taken at the sampled factories. The volume of hazardous wastes was calculated using the U.S. EPA figure of 10 percent of all wastes. U.S. EPA, *Report to Congress on Hazardous Waste Disposal* (Washington, D.C., June 1973), 5.

Table 3. Pre-1940 National Priorities List Sites, 1984

Industry	Number	On-Site Disposal	Contamination: Ground Water	Contamination: Surface Water
Mining	5	5	1	5
Primary Metals	10	10	10	1
Petro-Chemicals	10	10	5	2
Wood Treating	9	9	9	3
Municipal Landfills	10	4	9	1
Other	4	4	3	
Totals	48	42		

Source: U.S. EPA, *Hazardous Waste Sites*, 1984.

mining and manufacturing districts add to the documentation of persistent hazards associated with pre-1940 wastes.[17]

A final factor influencing the compilation of historical inventories is the relatively recent reliance on landfills. Prior to World War II, industrial wastes were often released into waterbodies where dilution was thought to be an adequate means of treatment. Since 1945, urban wastes have increasingly been interred in landfills which until very recently were considered safe. The shift to landfills in the past few decades has prompted a focus on land-based wastes.[18] Yet the possible accumulation of toxic sediments in stream beds is ignored by most inventories.

Manufacturers of Hazardous Waste

The inventory systems, although weak on long-term historical data, do provide valuable insight into the general location of unidentified hazardous substance accumulations. There is a strong correlation between states with large manufacturing sectors and hazardous waste sites, and this has not gone unnoticed. However, analysis of historic manufacturing processes has only touched on the scope of hazardous waste generation.[19] A review of several durable toxic materials will hint at the widespread use of hazardous materials in manufacturing districts.

17. U.S. EPA, *Hazardous Waste Sites*. English examples are discussed in Raymond P. Gemmell, *Colonization of Industrial Wasteland* (London: Edward Arnold, 1977), 35.

18. Joel A. Tarr chronicled the general pattern of diverting wastes from one sink to another during the last century. See Joel A. Tarr, "The Search for the Ultimate Sink: Urban, Air, Land, and Water Pollution in Historical Perspective," *Records of the Columbia Historical Society of Washington, D.C.* 51(1984), 1–29.

19. The most complete survey is Coates, *Nineteenth Century Technology;* see also Joel A. Tarr, "Historical Perspectives on Hazardous Wastes in the United States," *Waste Management and Research* 3 (1985), 95–102.

In 1923, occupational health expert Alice Hamilton wrote, "Lead is not only the most important of the metallic poisons, but it is probably the most important toxic element used in industry."[20] Her review of lead-related diseases focused on worker exposure, but in the context of this paper, where there was lead there was inevitably lead waste. Crushing and smelting operations left residue in the form of dust or slag which can continue to affect workers or residents in the vicinity of such operations. Significant exposure occurred in plants making batteries, ammunition, paint, piano wire, and plumbing supplies. Potters, printers, and typesetters also came into contact with dangerous levels of lead.[21] Despite recognition of the serious problems posed by lead, it remained the leading occupational hazard in 1941. In fact, the list of high-risk occupations grew to include glass making, tinning, the manufacture of lead alloys, the cutlery industry, automobile body works, and rubber producers.[22] Accumulations of lead dust at these types of industries could, if disturbed in later years, pose risks to workers and nearby residents. With the current interest in revitalizing "rust belt" industrial complexes,[23] release of lead dust will certainly accompany redevelopment.

Organic chemicals, such as benzene, toluene, and naptha, were distilled from coal and petroleum early in this century and they remain major environmental hazards. The most common means of exposure were inhaling fumes released in factories where these chemicals were present or consuming chlorine-treated water containing organics.[24] There were numerous sources of these products in 1914, including chemical cleaning plants, rendering operations, lacquer, varnish and India rubber industries, dye works, and coal gas plants.[25] T.N.T. poisoning of munitions workers during World War I alerted medical authorities to still another source of exposure.[26] Workers' reactions to gases given off by organic solvents ranged from headaches and dizziness to sensory paralysis.[27] By venting the fumes, employers reduced worker exposure; accidental and

20. Alice Hamilton, "Industrial Toxicology," in Frederick Peterson, ed., *Legal Medicine and Toxicology* (Philadelphia: Saunders Company, 1923), 774.

21. Hamilton, "Industrial Toxicology," 775–76; also see George M. Price, *The Modern Factory: Safety, Sanitation, and Welfare* (New York: John Wiley and Sons, 1914), 442–43; and Carey McCord, *Industrial Hygiene for Engineers* (New York: Harper and Brothers, 1931, 58–95.

22. Howard Collier, *Outlines of Industrial Medical Practice* (Baltimore: Williams and Wilkins, 1941), 231–33.

23. Ralph R. Widner, "Physical Renewal of the Industrial City," *Annals of the American Academy of Political and Social Science* 448 (1986), 47–57.

24. Robert H. Harris, "The Health Risks of Toxic Organic Chemicals Found in Groundwater," in C.C. Travis and E.L. Etnier, eds., *Groundwater Pollution: Environmental and Legal Problems* (Boulder: Westview Press, 1984), 63–64.

25. Price, *The Modern Factory*, 442.

26. Antonia Ineson and Deborah Thom, "T.N.T. Poisoning and the Employment of Women Workers in the First World War," in P. Weindling, ed., *Social History of Occupational Health* (London: Croom Helm, 1985), 89–107.

27. Hamilton, "Industrial Toxicology," 794.

intentional spills of solvents to the ground and to streams, however, were not uncommon. As organic chemicals entered public water supplies, they were mixed with chlorine and then delivered to homes throughout metropolitan areas.[28] Such exposures, although common, were generally intermittent. However, before automobile drivers created a demand for benzine, or gasoline, it was an unnecessary by-product of oil refineries that was commonly dumped on the ground or into streams. Domestic consumption of contaminated water was therefore a common experience downstream from refineries before 1920.

Arsenic was a third ingredient widely used in industry before 1940. It is highly toxic in concentrated form and debilitating if ingested in small quantities over lengthy periods. Paris green, an arsenate coloring agent used in wallpaper and paints, caused illness in homes and factories in the nineteenth century.[29] Its use in wallpaper was halted, but paint manufacturers continued to use Paris green well into this century. Lead arsenate pesticides were another troublesome product.[30] Increasing use of pesticides during the first quarter of the century broadened the impact to include not only farm families and factory workers,[31] but town residents consuming water drawn from contaminated sources.[32] In addition, glass, chemical, and metallurgical industries released arsenic-laden fumes which caused temporary air-borne exposure, while dumps of zinc slag and pesticide mixing operations have caused long-term contamination of ground water.[33]

Toxic materials were used widely by pre-1940 industries and the NPL listing strongly suggests that industries handling such wastes created accumulations of those same materials on site.[34] Thus, the search for hazardous wastes must start with industries handling hazardous materials. How wastes were treated and disposed, however, determined their ultimate fate.

Public Policy and Management Concerns

During the period from roughly 1880 to 1940 there were continuous efforts to reduce the amount of waste produced by industry. These included converting wastes to profit-making by-products and eliminating inefficiencies—both engineering solutions to an environmental problem.

28. Joel A. Tarr, "Industrial Wastes and Public Health: Some Historical Notes, Part I, 1876–1932," *American Journal of Public Health* 75 (1984), 1059–67.

29. Henry Carr, *Our Domestic Poisons* (London: William Ridgway, 1883), 6–7.

30. Hamilton, "Industrial Toxicology," 781.

31. A 1930s arsenic dump poisoned the drinking water of a small business in Minnesota. This well-known example of arsenic poisoning is described in U.S. EPA, *Hazardous Waste Sites*, 249. Coates, *et al.* suggest that ground-water contamination due to arsenic spills is not a likely source of persistent hazards, *Nineteenth Century Technology*, 5–12.

32. U.S. EPA, *Hazardous Waste Sites*, 244.

33. Ibid., 468.

34. Ibid.

Yet there was little incentive in the legal, economic, or technical framework of 1930s business to impel managers to purchase effective waste-treatment equipment.

Nuisance and riparian laws prohibited contamination of surface and ground water, but the enforcement of these statutes was lax and court decisions favoring the complainant were hard to come by.[35] Public health officials were most concerned with biological wastes, hence discharges of toxic wastes were implicitly sanctioned by early twentieth-century public policy.[36] German hydrologists even encouraged recharging a depleted aquifer with industrial wastes, an act reflecting the indifferent attitude toward toxic contamination of major water supplies.[37] Fear of driving industries away contributed to infrequent enforcement of nuisance statutes as well. In 1915, the Illinois Rivers and Streams Commission, whose duties included monitoring the condition of the state's waterways, advocated tolerance at the risk of losing jobs.

> Certain manufacturing wastes at the present state of the art of sewage purification are very difficult or impossible to treat with satisfactory results in entirely preventing stream pollution. In these cases it is a question of allowing a certain degree of local stream pollution or of abandoning the industry.[38]

Governmental patience with uninhibited pollution gave rise to a belligerent attitude among industrialists and forced private citizens to contest the fouling of waterways. Industry sympathizers bristled at even poorly financed and infrequent legal attacks:

> As in England, [the movement to halt water pollution] begat some rascally offspring, smart neighbors who discovered that nuisance suits against chemical and metallurgical corporations made a strong appeal to any jury in the land, and unscrupulous local politicians who learned that threats of injunctions or municipal ordinances were heavy well-spiked clubs to swing at the managers of such corporations.[39]

The combination of ineffective laws, infrequent enforcement, and strong resistance on the part of industry left consumers of surface and ground water subject to contaminated public water supplies throughout the 1930s.

Textbooks on business management overshadowed the subject of waste disposal with extensive discussions on the waste of inefficiency. Consequently, managers developed a business-like attitude toward the efficient movement of raw materials through a plant and for the development of

35. James A. Tobey, "Legal Aspects of the Industrial Wastes Problem," *Industrial and Engineering Chemistry* 31 (1939), 1320–22.

36. M. O. Leighton, "Industrial Wastes and their Sanitary Significance," *American Bureau of Public Health: Papers and Reports* 31 (1905), 29–40; also see Tarr, "Historical Perspectives."

37. C. F. Toulman, *Ground Water* (New York: McGraw Hill, 1937), 185.

38. Leroy Sherman, "Stream Pollution and Sewage Disposal with Reference to Public Policy and Legislation," Illinois Rivers and Lakes Commission, *Bulletin* 16 (December 1915), 6.

39. William Haynes, *American Chemical Industry*, vol. 3, (New York: Nostrand, 1945), 114.

marketable by-products.[40] This perspective is reflected in the plans of factory architects who paid little attention to where wastes would be collected or how to accommodate waste treatment facilities in plant designs.[41] The critical concern shared by managers and factory designers was to prevent wastes from hindering operations. Acceptable solutions were to haul wastes to a low spot on the factory grounds, which provided the beneficial side effect of reclaiming useless land, or releasing liquids into the nearest stream.[42] Overall, however, industrial decisionmakers felt little pressure to provide treatment for their wastes. Elimination of waste was not a question of how to dispose of process residue safely, but one of how least to interfere with the manufacturing process.

Industry has long claimed that the installation of waste treatment equipment would be financially devastating,[43] and a 1939 study estimating that it would cost American industry $900,000,000 to provide "practicable" treatment of their wastes confirmed this view.[44] Experimentation with waste technology increased dramatically during the 1930s. This sudden response to environmental problems caused by industrial effluent was sparked by federal programs supporting waste treatment. However, research was driven by the desire to find a return on the cost of pollution control, not the urge to purify streams.[45] The first option was to recover usable wastes,[46] but when no profitable by-product could be found, researchers were prone to recommend diverting industrial sewage to a municipal treatment plant.[47]

40. The leading advocate of industrial efficiency was Frederick W. Taylor, *The Principles of Scientific Management* (New York: W. W. Norton, 1911).

41. Price, *The Modern Factory*, 285–86; and A. R. McGonegal, "Plumbing and Sanitation of Industrial Buildings," *The Architectural Forum* 53 (1930), 431.

42. John Appleton, *The Iron and Steel Industry of the Calumet District*, University of Illinois Studies in the Social Sciences, vol. 13, no. 2 (1925), 80; and Lewis F. Thomas, *The Localization of Business Activities in Metropolitan St. Louis*, Washington University Studies, New Series, Social and Philosophical Sciences, no. 1 (1928), 95.

43. Garner Swartz, "Report of the Committee of Industrial Wastes," *American Bureau of Public Health: Papers and Reports* 29 (1903), 166.

44. U.S. Congress, *Water Pollution in the United States*, House Doc. 155, 76th Cong., 1st sess., 1939, 2.

45. C. L. Knowles, "Industrial Wastes from the Equipment Manufacturers' Viewpoint," *Industrial and Engineering Chemistry* 31 (1939), 1338–45.

46. Early examples of this genre reflect the desire to conserve natural resources during World War I. See William Berkeley, "Industrial Wastes: A Tax Paid to Ignorance," *Industrial Management* 54 (1917), 312–22; and Rockwood Conover, "Salvaging and Utilizing Wastes and Scraps in Industry," *Industrial Management* 56 (1918), 449–51. During the thirties the emphasis shifted to wringing a profit from by-products; see C. M. Baker, "Wastes and Pollution vs. Recovery for Profit," *Water Works and Sewage* 80 (1933), 296–98; and Shepard T. Powell, "Profits from Trade Wastes," *Chemical and Metallurgical Engineering* 40 (1933), 359–60.

47. This general position is expressed for all industries in Glenn V. Brown, "Classification and Treatment of Industrial Effluents," *Public Works* 68 (1937), 40–42. Examples from specific industries include U. F. Turpin, "Sewage Plant Rebuilt to Treat Rayon Wastes," *Engineering News-Record* 109 (1932), 780–82; H. Bach, "The 'Tank Filter' for the Purification of Sewage and Trade Wastes," *Water Works and Sewage* 84 (1937), 389–93; N. J. Ranney, "Treatment of Pickling Wastes," *Iron Age* 143 (1939), 24–27; and L. F. Harlow, "Waste Problems of a Chemical Company," *Industrial and Engineering Chemistry* 31(1939), 1346–49.

Not only would this insure some form of waste treatment and improve the manufacturers' public image, but it would shift the legal responsibility for stream pollution to the municipality.

Treatment and Disposal Practice

The primary public health concern during the 1930s was with liquid wastes which endangered potable water supplies; experimentation with waste recovery focused on liquid effluents. Certain industries did discover usable by-products, but inadequate markets for those items delayed construction of recovery units. An example is the iron and steel industry, which was a major nineteenth-century source of toxic wastes and one of the leaders in examining waste treatment technology. Numerous improvements were made in the methods of waste disposal during the early 1900s, such as controlling the emissions from bee-hive coke ovens and blast furnaces and reducing coal tar and ammonia liquor pollution.[48] Yet, phenols and pickle liquors (solutions containing sulphuric acid) remained as major waste concerns of the steel industry even after 1940.

Phenols caused disagreeable tastes in water supplies, especially those which were chlorinated. The U.S. Public Health Service estimated in 1925 that 60 to 75 percent of the 38,000,000 tons of still wastes were released into waterways[49] and the majority of these waterways flowed through densely settled portions of the country. In the steel district of southeast Chicago, for example, a survey of stream pollution listed three steel mills as major sources of untreated phenol releases in 1925.[50] By 1933 there were signs of phenol pollution control after each of the offenders installed treatment facilities.[51] One common method of treating phenolic wastes was to mix them with water and use the mixture as a quench liquor.[52] Phenols which were not destroyed in the quenching process percolated into the soil or flowed into surface-water bodies. Recognition that such practice was inadequate prompted a search for a more satisfactory method of disposal, but one that would keep costs low. Experiments were conducted with destruction of phenolic wastes in municipal sewage treatment works and it was determined that trickling filter and activated sludge plants could adequately treat coke and steel mill wastes

48. William Hodge, "Waste Problems of the Iron and Steel Industries," *Industrial and Engineering Chemistry* 31 (1939), 1329.
49. R. D. Leitch, *Stream Pollution by Wastes from By-Product Coke Ovens*, U.S. Department of Public Health Service, (Washington, D.C., 1925), 2.
50. H. R. Crouhurst, *Report on an Investigation of the Pollution of Lake Michigan in the Vicinity of South Chicago and the Calumet and Indiana Harbors, 1924–25*, Chicago Metropolitan Sanitary District, (Chicago, Illinois, 1926), Table 7.
51. Arthur Gorman, "Pollution of Lake Michigan: Survey of Sources of Pollution," *Civil Engineering* 3 (1933), 519–22.
52. Leitch, *Stream Pollution*, 2, and Hodge, "Waste Problems," 1366.

when mixed with domestic sewage.[53] How widely these methods were used is uncertain. Benzene absorption and phenol recovery were developed by the late 1920s, but inadequate markets for by-products discouraged implementation.[54]

Pickle liquors created the other serious environmental controversy for steel mills which produced between 500,000,000 and 800,000,000 gallons of acid wastes annually.[55] These acids were deadly to aquatic life, corroded sewer pipes, and disrupted the biological activity of sewage treatment plants. Consequently, cities denied treatment to acidic wastes and conservation groups sought to prevent their release into streams. As a result, industry engineers struggled to develop adequate treatment methods, but low-cost dumping remained the favored option. A 1939 survey of disposal methods reported that acid wastes were pumped into limestone caves, deep wells, abandoned mines, and exhausted oil and gas sands; they were collected in sand and gravel sumps near large bodies of water (allowing percolation into the water table) and sewered to streams.[56] None of these methods included treatment, although several effective, albeit costly, options were available. A comparison of five treatment processes found dilution to be unacceptable to municipal treatment plant operators and costly in terms of the water consumed. Neutralization, the second option, created troublesome deposits of lime in the sewer pipes and lime absorption was too costly. Cesspools were ruled out because acids moving through the soil could damage buried pipes and contaminate ground water. The survey found recovery of copperas the most satisfactory method, although there was insufficient demand for the product to make recovery profitable.[57] Critics of recovery countered that steel makers should not try to diversify into the chemical business and that acids could be adequately neutralized with limestone.[58] The facts that no clear solution emerged and that acid discharges continued suggest that little action was taken on any of the recommended treatments.[59]

Oil refineries generally relied on the least expensive means of waste treatment at the turn of the century. One industry spokesman revealed the unconcerned attitudes of early producers when he wrote, "The petroleum refining industry of forty years ago had no waste problem."[60] By this he meant that refiners dumped acids, oil emulsions, and gasoline in

53. Leitch, *Stream Pollution*, 2; Willem Rudolfs, "A Survey of Recent Developments in the Treatment of Industrial Wastes," *Sewage Works Journal* 9 (1937), 998–1017; and Bach, "The 'Tank Filter.' "

54. Hodge, "Waste Problems," 1366, 1376.

55. "Acid Disposal is a Big Problem," *Steel* 105 (1939), 60, 79.

56. Hodge, "Waste Problems," 1368.

57. Stuart E. Coburn, "Disposal of Acid-Iron Wastes from a Steel Mill," *Industrial and Engineering Chemistry* 20 (1928), 248–49.

58. Knowles, "Industrial Wastes," 54–55.

59. C. E. Colten, *Industrial Wastes in the Calumet Area*, 1869–1970, 64.

60. J. Bennett Hill, "Waste Problems in the Petroleum Industry," *Industrial and Engineering Chemistry* 31 (1939), 1361–63.

nearby waterbodies without any prior treatment and with no fear of litigation. After the creation of a water quality watchdog agency in 1927, Illinois refiners sought to eliminate the obvious oil slicks floating down stream from their plants. Although trade journals advocated separators as means of reducing visible oil releases,[61] some refineries turned to alternate sinks for the disposal of oily waste waters. Examples from two refinery districts illustrate the uneven progress of the 1920s and 1930s. The White Star Refinery in Wood River directed its effluent to a shallow lake on the nearby floodplain,[62] while an adjacent refinery installed a master separator to collect its oily wastes before they entered the Mississippi River.[63] Together, these actions protected the major watercourse in the area and satisfied the state agency.[64] Chicago-area oil refineries were releasing more than five million gallons of wastes daily in 1926,[65] and this effluent continued to contaminate Lake Michigan into the early 1930s.[66] It was not until the 1960s that most refineries at the south end of Lake Michigan had installed separators to eliminate direct discharge of oils.[67] The use of separators was fairly common throughout the industry by 1940, but the hope of developing profitable by-products hindered implementation of secondary waste treatment. Also, landfilling oily wastes simply tranferred the hazard from surface to ground water.[68]

Chemical industries used solid wastes to reclaim low ground and commonly neutralized acid and alkaline liquids.[69] Such treatment methods were considered adequate to prevent human exposure to harmful wastes, but it is now known that leachate can escape from landfills and toxic sediments can accumulate in stream beds. Other treatment techniques followed by the chemical industry were deep-well injection of brines, gradual release of phenols during high river stages,[70] and diversion of toxic substances to municipal treatment works.[71] Evaporation lagoons and percolation ponds, also common treatment facilities, allowed chemical

61. Ibid., 1361–62.

62. Illinois Appeals Court, Fourth District, "Shelby Loan and Trust Company *et al.*, v. White Star Refining Company," 271 *Illinois Appeals* 266 (May 1933), 266–69.

63. Illinois Environmental Protection Agency, Sanitary Water Board, Microfiche Records 1923–1952, Wood River File, Springfield, Illinois.

64. "Abatement of Industrial Waste Pollution in Illinois," *Public Works* 67 (1936), 18.

65. Crouhurst, *Report on an Investigation*, 10.

66. Gorman, "Pollution of Lake Michigan," 520–21.

67. U.S. Department of Health, Education and Welfare, *Report on the Quality of the Waters of the Grand Calumet River, Little Calumet River, Calumet River, Lake Michigan, Wolf Lake, and their Tributaries* (Chicago, Illinois, February 1965), Table VI-3b.

68. Tarr, "Search for the Ultimate Sink."

69. E. B. Besselievre, "The Disposal of Industrial Chemical Waste," *The Chemical Age* 25 (1931), 516–18.

70. I. F. Harlow, "Waste Problems of a Chemical Company," *Industrial and Engineering Chemistry* 31 (1939), 1346–49.

71. F. W. Mohlman and A. J. Beck, "Disposal of Industrial Wastes," *Industrial and Engineering Chemistry* 21 (1929), 205–209.

manufacturers to divert liquid wastes from surface waters to the ground.[72] So although concern with hazardous wastes was voiced, action directed toward effective elimination or destruction of these wastes was minimal and even the most serious problems were not resolved.

Conclusions

Environmental agencies have not ignored pre-1940 hazardous waste sites. Out of practicality, political pressure, legislative constraints, and popular perception, they have compiled inventories that focus on the recent past. The emphasis on recent activity has caused the omission of many older and sometimes reworked industrial areas. Yet in the four decades preceding 1940, American manufacturers produced significant quantities of durable hazardous wastes and disposed of them in an indifferent manner. The proximity of these older disposal sites to urbanized areas makes their discovery crucial, and public policy should give this fact greater recognition.

In analyzing the inherent historical shortcomings of the existing inventory systems, this paper has touched on several areas where possible improvements could be made. It is imperative to include those industries in operation before 1940 and to consider their wastes as potential hazards. To do this, inventories must take into account both active and inactive businesses, and since much waste disposal took place on site, all manufacturers which handled hazardous materials should be considered possible sources and repositories for hazardous wastes. This would hold true for both pre- and post-1940 industries.

The addition of defunct industries would increase the analytical potential of the data bases, but additional historical research is needed to make that analysis useful. More in-depth reporting on the industrial technologies creating hazardous wastes will help fine tune the search for possible waste sources. Further research on the social, political, and economic factors affecting the implementation of waste treatment facilities will provide a context for assessing the acceptance of waste management services. Finally, a detailed review of industrial waste treatment technology will offer a chronology of the services available. Together, these historical components will allow analysis of historical hazardous waste sites with a relatively reliable level of accuracy and thereby improve the utility of the overall data sets.

72. Numerous examples of waste impoundments can be found among the NPL sites included in U.S. EPA, *Hazardous Waste Sites*, 1984.